SYSTEM AND METHOD FOR DELIVERING A TARGET VOLUME OF FLUID

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. application Ser. No. 15/646,038 filed Jul. 10, 2017 and issued on Mar. 3, 2020 as U.S. Pat. No. 10,576,194, which is a division of U.S. application Ser. No. 14/297,183 filed Jun. 5, 2014 and issued on Jul. 25, 2017 as U.S. Pat. No. 9,713,667, which is a continuation of U.S. application Ser. No. 11/926,700 filed Oct. 29, 2007 and issued on Sep. 2, 2014 as U.S. Pat. No. 8,821,475, which is a divisional of U.S. application Ser. No. 10/412,658 filed on Apr. 10, 2003, now issued as U.S. Pat. No. 7,544,179 on Jun. 9, 2009, which claims priority from U.S. Provisional Application Ser. No. 60/371,894 filed on Apr. 11, 2002, all of which are hereby incorporated herein by reference.

TECHNICAL FIELD AND BACKGROUND ART

[0002] The present invention relates to fluid delivery systems, and in particular to systems and methods for accurately delivering a target volume of fluid to a destination.

[0003] Such systems regulate the rate of flow of fluid through a line. Some examples of fluid delivery systems are peritoneal dialysis machines and intravenous fluid delivery systems. These systems may include a permanent housing which does not come into direct contact with the transporting fluid and into which a fluid-exposed disposable cassette is placed. The disposable cassette includes flexible membranes, or other structures that respond to pressure and that separate the permanent components from the fluid being delivered. Examples of such fluid delivery systems and their sub-components (e.g., pressure conduction chambers, flow measurement systems and valves) are disclosed in U.S. Pat. Nos. 4,778,451, 4,826,482, 4,976,162, 5,088,515, 5,178,182 issued to Kamen, U.S. Pat. No. 5,989,423 issued to Kamen et al. and U.S. Pat. No. 6,503,062 issued to Gray et al. These patents are all hereby incorporated herein by reference.

[0004] One problem with respect to fluid delivery systems, such as in peritoneal dialysis, arises when treating subjects with low fill volume capacities, such as a child. For example, in peritoneal dialysis systems, a fill volume of 1000 mL or less generally indicates a low fill volume while fill volumes of greater than 1000 mL are typical for an average adult's fill volume. Thus, a single fluid delivery system may not be appropriate for treating both an average adult and a child.

[0005] Another problem arises with respect to fluid delivery systems when two or more fluids from two or more sources must be delivered to a subject or patient simultaneously and in a particular ratio. It is difficult to maintain a consistent ratio of the different fluids for simultaneous delivery to the subject because each source may deliver its solution to the system at different rates and/or in different volumes. Consequently, it is difficult to maintain a consistent ratio of the different fluids in the fluid delivery system at any one time.

SUMMARY OF THE INVENTION

[0006] In a first embodiment of the invention, a method for delivering a target volume of fluid to a destination includes delivering a first volume of fluid to the destination in increments each having approximately a first incremental volume, the first volume of fluid being less than the target volume. A second volume of fluid is then delivered to the destination in increments each having approximately a second incremental volume. The second incremental volume is less than the first incremental volume, and the sum of the first volume and the second volume is approximately equal to the target volume.

[0007] Delivering the first and second volumes of fluid to a destination may include delivering the first and second volumes of fluid parenterally to a human subject. Similarly, delivering the first and second volumes of fluid to a destination may include delivering the first and second volumes of fluid to a fluid reservoir and/or delivering the first and second volumes of fluid to a container. Such a container may be a heating bag, such as may be used in conjunction with a peritoneal dialysis system, and/or a pump chamber. In accordance with a related embodiment, the first volume may be approximately equal to the target volume minus a finish volume and the second incremental volume may be less than the finish volume. In a related embodiment, the second incremental volume may be less than one third the finish volume.

[0008] In accordance with another embodiment of the invention, a system for delivering a target volume of fluid to a destination includes a fluid control module for delivering a first volume of fluid to the destination in increments each having approximately a first incremental volume, the first volume of fluid being less than the target volume. The fluid control module also delivers a second volume of fluid to the destination in increments each having approximately a second incremental volume, the second incremental volume being less than the first incremental volume. The sum of the first volume and the second volume is approximately equal to the target volume. The system also includes a valve arrangement for controlling fluid communication to the destination and a controller for determining the volume of fluid delivered to the destination and for controlling the valve arrangement and the fluid control module. The fluid control module may deliver the first and second volumes of fluid to a human subject and the first and second volumes of fluid may be delivered parenterally. Similarly, the fluid control module may deliver the first and second volumes of fluid to a fluid reservoir and/or a container such as a heating bag and/or a pump chamber.

[0009] In accordance with related embodiments, the first volume may be approximately equal to the target volume minus a finish volume and the second incremental volume may be less than the finish volume. For example, the second incremental volume may be less than one third the finish volume.

[0010] In accordance with a further embodiment of the invention, a method for simultaneously delivering a target volume of fluid from two sources in a desired ratio to a common destination includes delivering a first volume of fluid from a first source and a second volume of fluid from a second source to the destination in increments each having approximately a first incremental volume, the first incremental volume of fluid being substantially less than the target volume. After delivery of a first incremental volume of fluid from the first source and the second source, the volume of fluid delivered to the destination from the first source and the volume of fluid delivered to the destination from the second source is measured. Delivery of the first volume of fluid to the destination is suspended when the first